Secrets of industry' for 'common men'

‘SECRETS OF INDUSTRY’ FOR ‘COMMON MEN’: CHARLES DE BOVELLES AND EARLY FRENCH READERSHIPS OF TECHNICAL PRINT

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Where Charles de Bovelles has a reputation at all, it is as a highly innovative philosopher in the intellectual mold of Nicolas of Cusa, Giovanni Pico della Mirandola, or perhaps Giordano Bruno.[1] But beyond being possessed of a mathematical curiosity and turn of imagination, the Picard canon was also deeply invested in the early sixteenth-century efforts to rework French as a language with a distinctive cultural heritage.[2] He experimented with arithmetical and geometrical theory in French and wrote studies of the language itself, such as a collection of French proverbs and a short study of French’s origins, via the ancient Druids, in Greek—like many other such theorists, he composed these theoretical studies of the vernacular in Latin.[3]

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[1] Ernst Cassirer revived interest in Bovelles in *Das Erkenntnisproblem in der Philosophie und Wissenschaft der neueren Zeit*, 2 vols., (Berlin: 1920), vol. I, 61–72, and especially his edition of Bovelles’ *De sapiente* appended to *Individuum und Kosmos in der Philosophie der Renaissance* (Leipzig – Berlin: 1927). Bovelles’s key insight included a Pican confidence in the intellectual powers of man to perfect and even co-create himself, a reading powerfully extended by Emmanuel Faye in *Philosophie et perfection de l’homme: De la Renaissance à Descartes* (Paris: 1998). Fundamental bibliography includes: Victor J.M., *Charles de Bovelles, 1479-1553: An Intellectual Biography* (Geneva: 1978); Trédaniel G. (ed.), *Charles de Bovelles en son cinquième centenaire, 1479-1979* (Paris: 1982); Ferrari M. -- Albertini T. (eds.), *Charles de Bovelle's* Liber de sapiente, special issue of *Intellectual History Review* (2011); Klinger-Dollé A.-H., *Le* De sensu *de Charles de Bovelles (1511). Conception philosophique des sens et figuration de la pensée. Suivi du texte latin du* De sensu*, traduit et annoté* (Droz, Geneva: 2016); and Klinger-Dollé A.-H. - Faye E. - Sfez J. (eds.), *Bovelles philosophe et pédagogue* (Paris: *forthcoming*). An especially rich account of Bovelles’s life can be gleaned from Margolin J.-Cl., *Lettres et poèmes de Charles de Bovelles* (Paris: 2002).

[2] To sense this enormous moment in the formation of French literature, see DellaNeva J.A., *Unlikely Exemplars: Reading and Imitating beyond the Italian Canon in French Renaissance Poetry* (University of Delaware Press, Newark: 2009).

[3] Bovelles Charles de, *Proverbiorum vulgarium libri tres* (Paris, Galliatus Pratensis: 1531); Bovelles Charles de, *Liber de differentia vulgarium linguarum* (Paris, Robert Estienne: 1533).

Bovelles also wrote three vernacular manuals of geometry. He published the *Geometrie Francois* in 1511, the same year that the first illustrated edition of Vitruvius's ten books on architecture was published in Venice. Unlike Vitruvius, however, Bovelles claimed to have written his book not for elite, Latinate readers, but for those he called 'common' [*plebes*] workmen. Today, this book exists only in few copies, and it was not reprinted.[4] But there are more copies of a similar book Bovelles published in 1542, the *Livre singulier et utile touchant l'art et practique de geometrie*, again claiming a readership of craftsmen. Demand ensured a revised edition in 1547 (with the new title *Geometrie practique*), which was republished at least five times in French, besides Dutch and Latin translations, into the early seventeenth century.[5] French mathematics had found a broader readership. Bovelles's practical geometry is a

[4] Bibliothèque municipale de Rouen, shelfmark Leber 1159; Bibliothèque de Gand, Centrale Bibliotheek, shelfmark A 11066(2); Bibliothèque municipale de Blois, shelfmark I 958, digitized at < http://www.bvh.univ-tours.fr/Consult/index.asp?numfiche=715> (last accessed 6 January 2017). Jean-Claude Margolin, in an important article of 1976, placed Bovelles at the beginning of an emerging tradition of French mathematical teaching, with a focus not on Bovelles' earlier theoretical treatises, but more on the vernacular handbook that became popular in 1542. Margolin J.-Cl., "L'enseignement des mathématiques en France (1540-70): Charles de Bovelles, Fine, Peletier, Ramus", in *French Renaissance Studies, 1540-70: Humanism and the Encyclopedia*, ed. P. Sharratt (Edinburgh: 1976) 109–155. In this article, Margolin claimed that Bovelles's 1511 *Geometrie Francoys* was the first printed vernacular mathematics, a point René Taton repeated, calling the volume 'the direct heir of the commentaries of Boethius and Bradwardine which formed the basis of Paris university education at the end of the fifteenth century'. Taton R., "Bovelles et les premiers traités de géométrie en langue française", in *Charles de Bovelles en son cinquième centenaire, 1479-1979: actes du colloque international tenu à Noyon, les 14-15-16 septembre 1979* (Paris: 1982) 196. In contrast, Taton judged the 1542 geometry to be a 'confused mixture' of mathematics, esotericism, and natural philosophy, all of which set him outside the lineage of modern science. When Margolin responded in 1993, he emphasized that Bovelles's 1542 geometry fit a growing trend to write learned literature in the vernacular. Moreover, even though Bovelles's rigor left much to be desired—this was by no means cutting edge mathematics—Margolin identified the work's contribution not in mathematics but precisely in its 'composite character'. What Taton called a 'confused mixture' Margolin saw as an important effort to popularize his anthropological and 'cosmo-theological' Latin theory by dressing it in practical garb. Margolin J.-Cl., "Une Géométrie fort singulière: la Géométrie pratique de Charles de Bovelles (Paris, S. de Colines, 1542)", in *Verum et Factum. Beiträge zur Geistesgeschichte und Philosophie der Renaissance zum 60. Geburtstag von Stephan Otto* (Frankfurt am Main: 1993) 445.

[5] Bovelles Charles de, *Geometrie en françoys. Cy commence le Livre de l'art et Science de Geometrie, avecques les figures sur chascune rigle au long declarees par lesquelles on peut entendre et facillement comprendre ledit art et science de Geometrie* (Henri Estienne, Paris: 1511); Bovelles Charles de, *Livre singulier et utile, touchant l'art et practique de Geometrie, composé nouvellement en Francoys* (Simon de Colines, Paris: 1542); Bovelles Charles de, *Geometrie practique […] nouvellement par luy reveue, augmentee et grandement enrichie* (Paris, Reginald Chauderon: 1547). The 1547 edition was printed again in 1551, 1555 (twice), 1557, 1566, and 1608. See Appendix A of Oosterhoff R.J., *Mathematical Culture in Renaissance Paris: University, Print, and the Circle of Lefèvre d'Étaples*, Ph.D. dissertation (University of Notre Dame: 2013).

key case study because it self-consciously claims to be a practical text—furthermore, it is one of the first French practical geometries to be printed, and thus sheds light on the sources and aims of newly popular 'practical' genres that have long occupied historians of science and technology.[6]

Although previous historians have assumed that the advertised artisanal audience was merely a trope, Pascal Brioist has recently refocussed study on the question of Bovelles's relation to artisanal practice.[7] Reading the text in the light of sixteenth-century architectural and military practical manuals, Brioist extends an observation made by René Taton and Jean-Claude Margolin: that Bovelles's language regularly refers to material and physical conditions of figures, implying that this geometry belongs to craftsmen, not scholars. Brioist also cites places where Bovelles drew on his journeys through Germany and the Low Countries to give concrete examples, such as the difference between German tables (usually square) and French ones (usually rectangular). This is a much different picture than that given by Taton and Margolin; Brioist shows Bovelles not only trying to anticipate what information might be useful in practice, but attentively noting and assembling regional differences in artisanal practice.

My own focus will be Bovelles's successive revisions of his practical geometries, which help us see the difficulties of two forms of translation during the

[6] The developing relationship between craft and print is a key theme in Kusukawa S. – Maclean I. (eds.) *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe* (Oxford: 2006). A useful review of the historiography and overview of various new technical genres is Long P.O., *Artisan/Practitioners and the Rise of the New Sciences, 1400-1600* (Corvallis, OR: 2011). The cultural significance of new French technical works was already noted by Davis N.Z., "Sixteenth-Century French Arithmetics on the Business Life", *Journal of the History of Ideas* 21 (1960) 18–48; for most recent studies of French in particular, see now Tura A., *Fra Giocondo et les textes français de géométrie pratique* (Geneva: 2008).

[7] I am grateful to Pascal Brioist for sharing his paper prior to publication: "Les singularités de la géométrie pratique de Charles Bovelles", forthcoming in *Bovelles philosophe et pédagogue*. This paper provides the closest analysis of Bovelles's mathematical practice to artisanal use.

crucial early sixteenth century just as Joachim du Bellay, Jacques Peletier du Mans, and others in Bovelles's circles were reimagining French as a literary and technical language. These geometries were translations in the usual sense of rendering Latinate texts into French. But they also attempted to translate expertise from one sphere to another, from library to workshop. By claiming (in Latin) to write for the *vulgari*, Bovelles proffered his Latin knowledge to a French audience of workmen.

The difficulties of translating expertise come into view when we ask: who was the readership for Bovelles's French geometry? Was it the early Republic of Letters, or was it the rising class of artisans who were engaging with the published word? In an effort to answer this question, I consider how Bovelles presented practical geometry in 1511, 1542 and 1547. By 1547, we see him imagine a growing public which was increasingly interested in technical books and the language of practical secrets as entertainment.

Imagining Mathematical Publics

Bovelles belonged to the Parisian circle of university humanists around Jacques Lefèvre d'Étaples. With Josse Clichtove, Bovelles was one of Lefèvre's closest collaborators at the Collège du Cardinal Lemoine, and was interested in what we might call the popularization—or, in their terms, 'vulgarization'—of learning. Around 1500, the circle produced textbooks and introductions used to simplify the Latin learning of the university; by the 1530s, they had also presented the Bible in French, and composed Latin-French grammars. They formed the core of Marguerite de Navarre's network, out of which grew the diverse vernacular literary projects of the du Bellays, Sceve, Ronsard

and Jacques Peletier, the generation which reinvented French as a literary language.[8] In this context, writing in the vernacular was a potent experiment.

Bovelles and his Paris circles, I would argue, also fostered an emerging reading public for mathematics, first in Latin and increasingly in French. By 1526 the instrument maker, designer of engravings, and teacher of mathematics Oronce Fine could claim that he was publishing an *aequatorium*, an instrument for calculating the locations of planets, for the use of a 'mathematical republic'.[9] But how do we get at these publics? The most rigorous tool at our disposal, perhaps, is the history of reading, seeing who a text's readers were, and what they made of these texts. This path is not available in this case, since I am aware of only three exemplars of the first book—none annotated.[10]

Another line of evidence lets us say something about this reading public. In the early sixteenth century, we find a growing *expectation* or *promise* of utility surrounding mathematics, injected into a developing sense of 'public' in early modern Europe.[11] Lefèvre and others intended their books to be patronized, bought, and used by a public that was not necessarily mathematical, but found university mathematics useful for public goals. The Greek émigré George Hermonymus convinced Lefèvre to restore the discipline by noting (as Plato had) that mathematics is 'of the greatest importance not only to the republic of letters, but also to the civil republic'.[12] In another letter, Lefèvre

[8] Reid J.A., *King's Sister-Queen of Dissent: Marguerite of Navarre (1492-1549) and Her Evangelical Network*, 2 vols. (Leiden: 2009).
[9] Fine claimed that he devised his aequatorium for the benefit of the 'respublica mathematica'. Fine Oronce, *Aequatorium planetarum, unico instrumento conprehensum, omnium antehac excogitatorum, et intellectu et usu facillimum* (Paris, Nicolas Calceolarius: 1526), fol. a2v. See Oosterhoff R.J., "Lovers in Paratexts: Oronce Fine's Republic of Mathematics", *Nuncius* 31 (2016) 549-583.
[10] See note 4.
[11] Foundational works on the early modern origins of publics include Habermas J., *The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeois Society*, trans. T. Burger (Cambridge, MA: 1962; 1991); Anderson B., *Imagined Communities: Reflections on the Origin and Spread of Nationalism* (London: 1992).
[12] Lefèvre d'Étaples Jacques, *Textus de sphera Johannis de Sacrobosco, cum additione (quantum*

related the insights of the philosophers to the immediate practical benefits of mathematics: 'Therefore, take away numbers and their learning and you will leave laws unkept, justice will be left blind, there will be no rules of [musical] modulation found, no entry to the contemplation of the heavens, and the mysteries of sacred letters [i.e. Scripture] will be obscured—as indeed will be the universal philosophy which includes the understanding of both human and divine things'.[13] Some years later, Oronce Fine would repeat this claim to his new royal patron, Henry II of France: 'mathematics provides the sweetest fruit for the use of the community of the kingdom, and the safe care of the republic'.[14] Of course, such promises are cheaply made to prospective patrons. Nevertheless, the fact that such promises *were* made indicates that these patrons—high-ranking officials and royalty—could be openly held accountable to some notional public, or what Benedict Anderson has called an 'imagined community'.[15] Those making such promises believed, at the very least, that there was enough of a public that such appeals would matter to their prospective patrons. In the absence of annotations and other evidence about a public, we can usefully consider what community that printers and authors *imagined* in their works, recalibrating as successive editions failed and succeeded.

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necessarium est) adiecta, novo commentario nuper edito ad utilitatem studentium philosophice parisiensis academie, illustratus (Paris, Wolfgang Hopyl: 1495), fol. a1v. 'non modo reipublicae litterariae sed et civili momentum habent maximum'.

[13] Ibidem, fol. a4r. (= Rice E.F. (ed.), *The Prefatory Epistles of Jacques Lefèvre d'Étaples and Related Texts* (New York: 1972), ep. 5, 18.) 'Tolle igitur numeros numerorum disciplinam, leges imperficis, iustitia caeca relinquitur, nulla modulationum reperietur regula, nullus caelestium contemplationum aditus, sacrarum litterarum delitebunt mysteria, immo et universa philosophia qua pariter humanorum divinorumque cognitio describitur'. This section of the note had wider currency, for example excerpted by Caesarius Johannes (ed.), *Introductio Jacobi Fabri Stapulensis in Arithmeticam; Ars supputandi Clichtovei; Epitome rerum geometricarum Bovilli* (Deventer, R. Pafraet: 1507), fol. A2v.

[14] Fine Oronce, *De rebus mathematicis hactenus desideratis libri IIII* (Paris, Michel Vascovan: 1556). See also Oronce Fine, *Protomathesis* (Paris, G. Morhii: 1532), fol. AA3r. Here Fine promised that the recovery of pure mathematics would help theologians, philosophers, physicians, judges, and indeed all aspects of civil order.

[15] Anderson, *Imagined Communities*. See especially chapter 3, "The Origins of National Consciousness", for an argument about print-as-commodity at the origins of publics. For further reflection on this theme, see Watts J., "The Pressure of the Public on Later Medieval Politics", in Clark L. – Carpenter C. (eds.), *Political Culture in Late Medieval Britain* (Woodbridge: 2004) 159–180.

Failure (1511)

The *Geometrie en Francoys* Bovelles first published in 1511 was considerably reimagined for the *Geometrie practique* thirty years later. The long gap suggests that Bovelles first misjudged his public.

In the preface of 1511, he invoked the trope that friends had begged him to publish a geometry in French:

> a plerisque amicorum instigati, hanc vernacula lingua Geometriam cudimus, in qua partim speculari, precipue vero operari et singula perficere edocemus. In hac enim magis rei utilitati ac usui, quam sermonis honestati studuimus. […] Haud ergo latinis aut speculativis, sed factivis plebeisque viribus, hoc gallico sermone conscriptum exhibemus opusculum. [16]

> I was instigated by many friends to print this Geometry in the vernacular tongue, in which I teach partly to speculate, but mostly to work and to construct each thing. For in this I sought the use and utility of the matter rather than the integrity of words. […] I therefore offer this little book, written in French, not to Latin or speculative men, but to constructive and common men.

Yet it was no straightforward choice for an arts master to write in French—Bovelles wrote this preface in Latin. The tension between Bovelles's learned context and his popular aims was already apparent on the title page, which announced the

[16] Bovelles, *Geometrie en françoys* (1511) [1]v.

subject as 'ledit art et science de Geometrie' [this art and science of geometry], but offered as sole ornament a woodblock depicting souls in the cosmos speculating on the zodiac, a figure more fitting to heavenly theory than earthly practice.[17]

And so, despite its claim of a 'vulgar' readership, the book mixed registers in both format and contents. Though printed in quarto, it used the Gothic typeface that Henri Estienne normally used for Latin, mostly prestige texts. One might contrast another early printed practical geometry in French, by Pierre Verney around 1530,[18] which employed the 'dagger' version of 'batard' most often used to print and copy vernacular texts.[19] Even after the title page, the visual program of Bovelles's book advertised to a learned public, with few accommodations to the artisanal audience it claimed in the Latin preface. In particular, Bovelles's images are a curious mixture of theoretical and practical conventions. Consider drawings illustrating the same kind of operation, measuring the volume held by a cylindric hollow. Where Verney's woodcuts illustrate a man squinting through the instrument to measure a tower or well [Fig. 1a], Bovelles's images include only the figure in question, forcing the reader to focus on the mathematical abstraction more than the material context [Fig. 1b]. This choice was not

[17] In this case, the printer seems to have reused a woodcut that was used (more appropriately) in Bovelles' magnum opus, published that same year: Bovelles Charles de, *Liber de intellectu; Liber de sensu; Liber de nichilo; Ars oppositorum; Liber de generatione; Liber de sapiente; Liber de duodecim numeris; Epistole complures. Insuper mathematicum opus quadripartitum: De numeris perfectis; De mathematicis rosis; De geometricis corporibus; De geometricis supplementis* (Paris, Henri Estienne: 1511), 29v.

[18] Verney Pierre, *Succinte, briefve et compendieuse Collection Geometrale* (Jehan Pelluti, Metz: [c. 1530]). Verney may also be the author of some prognostications, first in Latin but later published in French in Lyon (1539). The only published information on Verney I have found is Tura, *Fra Giocondo et les textes français de géométrie pratique*, 55, 71. The book follows closely the division of medieval French geometries into *altimetrie, planimetrie,* and *solimetrie* (i.e. the study of heights, surfaces, and solids).

[19] Henri Estienne did not commonly print in the vernacular, so the shop may not have invested in appropriate type. See examples in Renouard A.A., *Annales de l'imprimerie des Estienne; ou, Histoire de la famille des Estienne et de ses editions* (Paris: 1843). The distinction between Gothic and *batard* should not be overstated, and many counter-examples should be expected. But during the fifteenth century and the first part of the sixteenth, it appears that printers did generally try to distinguish the type they used for Latin and vernacular books. For example, Antoine Vérard, who printed much more in the vernacular than did Estienne, distinguished quite clearly between the typefaces used in his Latin and his vernacular books.

consistent. In other places Bovelles's images admitted the materiality of the tasks they illustrated by shading in objects that, in the text, Bovelles identified as wood or stone.

[insert figure 1 here]

The book's textual contents matched its jumbled visual format, mingling practical and theoretical concerns. Again, first consider Verney's text, which closely follows the medieval French tradition of practical geometry. The first text actually known as *Geometrica practica* is thought to be by Hugh of St Victor in the twelfth century, who divided geometry into the measurement of heights, surfaces, and volumes (*altimetria, planimetria, cosmimetria*). French geometries as early as 1275 took on the same division, focusing on the use of astrolabes or quadrants in measurement.[20] Verney's printed French geometry of c. 1530 followed this tradition closely, simply presenting a series of problems in *altimetrie, planimetrie,* and *solimetrie* (the last term used synonymously with stereometry).[21] Such texts showed little concern for mathematical demonstration, but focussed on practical construction. For example, they listed the steps necessary accurately to deploy a Jacob's Staff when measuring the height of a tower.

Bovelles's *Geometrie en francoys* tried to chart a course between theoretical geometry and this artisanal, 'constructive' tradition. Bovelles offered a comprehensive overview of geometrical objects, which he called the 'principles' (points, lines, surfaces,

[20] Shelby L.R., "Geometry", in Wagner D.L. (ed.), *The Seven Liberal Arts in the Middle Ages* (Bloomington: 1983) 203. The first French Pratike de geometrie again was heavily influenced by the Latin tradition of *agrimensores*, put in iconic form by Hugh of St Victor; see Victor S.K., *Practical Geometry in the High Middle Ages,* Artis cuiuslibet consummatio *and the* Pratike de Geometrie (Philadelphia: 1979).
[21] Verney, *Collection Geometrale*.

bodies).[22] In contrast, Verney simply began *in medias res*, with instructions for basic problems of measuring heights, areas, and volumes, notably using the ancient instrument of the Jacob's Staff. Bovelles began by identifying geometrical objects: points, lines, surfaces, and bodies. He proceeded in a Euclidean fashion, by giving propositions that were to build up into a larger mathematical narrative. He served his practical goals by reformulating the propositions and demonstrations of Euclidean geometry into constructive elements: *rules* and *problems*. The rules in each book showed how to construct a particular shape, such as how to 'enlarge a given square in any proportion';[23] problems or questions tended to be 'chiefly useful to carpenters and masons', such as an example in the third chapter showed how to translate spheres into a column of the same volume.[24] In a word, Bovelles's book was hybrid. It offered the systematicity of an academic tract, but of constructive geometry instead of demonstrative.

Whether simply because of the book's austere visual program, or more because of its apparently theoretical text, craftsmen did not flock to bookstalls. Bovelles's book, I suspect, fell between the needs of two readerships: craftsmen found it unnecessary to learn the conceptual underpinnings of practical techniques they probably already knew, while few literary elites were yet interested in the mechanical arts.

Finding a Public (1542)

[22] The motivation behind this language of 'principles' can be glimpsed in Bovelles's expansion on the them in 1542, where he described these principles as the geometrical analogues to the integers 1,2,3,4 in Pythagorean number theory. Bovelles, *Geometrie practique* (1542) 3v–4r (preface).
[23] *Geometrie en francoys*, 12v.
[24] Ibidem, 32v: 'Sensuyvent aucunes questiones en la pratique de Geometrie pour la reduction de la spere pyramide, cube, et colonne a equalite. Et sont ces choses utiles principallement aux charpentiers et massons'.

By 1542, a mathematical public appears to have emerged. In that year Bovelles published a new practical geometry, titled *Livre singulier et utile, touchant l'art et practique de Geometrie* [A singular and useful book, concerning the art and practice of geometry]. Once again, Bovelles claimed an artisanal readership, citing 'certain craftsmen and manual laborers' who had requested that he write the book for them 'in the vulgar language', even though he was unaccustomed to writing in his mother tongue. Nevertheless, the vulgar tongue did not guarantee popularity—Bovelles complained that printers had promised 'mountains of gold' but in the end only 'gave birth to a mouse'—apparently they were hesitant to fully engage Bovelles's project.[25]

In the end, the book was finally published with the support of Oronce Fine, who by this time had been the royal professor of mathematics in Paris for over a decade.[26] Fine brought the project both a popular audience and special skills, as Bovelles acknowledged in the preface. On hearing that the work needed a printer, he remembered, Fine had promised two things:

> Duo protinus ingenue spopondit: se quidem cum primis daturum operam, ut aereis typis invulgata, plurimis esset usui; figurarum quoque quas ibidem frequentius inscripsi, futurum ligneis in tabellis pictorem. Necnon (quod praecipuum est) adversum mendas observaturum vigiles praeli excubiat. [27]

that he would himself give the work to printers, to be made popular in print, so

[25] Bovelles, *Livre singulier* (1542), fol a2r: 'et quidam ex Parisiensibus Chalcographis, in illius excussione aureos polliciti montes, ridiculum murem peperissent'. The reference is to Horace, *Ars poetica* II.3.139.
[26] Bibliography on Fine's career can be found in Marr A. (ed.), *The Worlds of Oronce Fine. Mathematics, Instruments and Print in Renaissance France* (Donington: 2009).
[27] Bovelles, *Livre singulier* (1542), fol. a2r–v.

> that it could be used by many; and also that the figures which I had everywhere drawn, he would shape on blocks, and (what is most important) he would take vigilant care that errors be corrected in press.

In other words, Bovelles not only needed Fine's support to ensure relations with Paris printers and for correcting the proofs in press, but he also required his technical expertise for designing woodblocks.

Fine's expertise as a craftsman, particularly in designing adequate woodcuts to accompany the text, should not be overlooked. By this time Fine was well known as a mathematical practitioner, also for his own craftsmanship. He had designed important frontispieces for Lefèvre's circle in the 1520s, and he became widely known for crafting instruments. Antoine Mizauld, his student, later recalled that Fine employed craftsmen to work out of his house, which was always full of bishops, courtiers, and important Parisians who came to see the marvellous instruments Fine made with his own hands.[28]

Bovelles advertised that the book had been 'composé nouvellement' [newly composed], and indeed it was very different from the 1511 *Geometrie*. Some of this was simply due to updated print conventions introduced by the printer Simon de Colines: a more elegant italic typeface, foliated capitals, and Fine's distinctive, elegant woodcuts [Fig. 2]. But it was not just on the strength of better production values that the book succeeded. The first page includes a poem to the reader, promising not only understanding of measurement, but also the 'secretz d'industrie'; the poem then enjoined the reader to deploy the geometer's instruments, the square, rule, and compass, with illustrative woodcut below. Images progressed from simple lines to actual objects;

[28] Mizauld Antoine, "Vita Orontii", in Fine, *De rebus mathematicis hactenus desideratis libri IIII*, fol. *6r.

these included vessels complete with handles, towers with pyramidal roofs, and even the geometrical structures of carts.[29]

[insert figure 2 here]

The contents of the 1542 practical geometry also shifted. Bovelles did not give up the effort to present systematically the basics of geometrical objects, from point to solid. But he compressed the introduction to concepts, getting quicker to the construction of useful figures. While explaining constructions, he vacillated between the kind of description that belonged to theoretical treatises, and careful attention to material figures, as when teaching how to use a compass: 'The curve is produced by means of the compass, which steadies the hand to make the turn'.[30] Moreover, Fine's woodcuts—perhaps especially significant for a practical audience—changed the book's emphasis. The stronger visual program of concrete objects (instead of abstractions) went beyond the 1511 geometry, beyond mere cubic and circular vessels. The seventh chapter in particular addressed how to put bells in harmony, how the four legs of a horse conform to geometrical norms (*nature sans cause riens ne fait*) [nature does nothing without a cause]; the geometrical proportions of wagon loads, and the equal height and arm extension of a human body, as well as the symmetrical arrangement of the organs of sight, smell, and hearing.[31]

[29] Bovelles, *Geometrie practique* (1542) 47v, 48v, 51r.
[30] Ibidem, 6r: 'La ligne oblique, se produyt par le moyen du compas, par lequel la main prent asseurance, à faire le tour'.
[31] Bovelles had a longstanding interest in figuring the senses, with and without mathematics. See Klinger-Dollé A.-H., *Le* De sensu *de Charles de Bovelles (1511)*.

Verney, c. 1530	Bovelles, *Geometrie en francoys*, 1511	Bovelles, *Livre singulier*, 1542	Bovelles, *Géométrie practique* (2nd ed. of *Livre singulier*), 1547
1. Altimetrie 2. Planimetrie 3. Cosmimetrie	1. Lines 2. Surfaces 3. Bodies	1. Principles, dimensions, circles 2. Angular shapes 3. Figures inscribing and circumscribing circles 4. Quadrature of the circle 5. Dimensions of bodies 6. Cubing of the sphere 7. Explanations of bells, horses, carts, etc.	4. *Two new propositions* 7. *Twenty-one new propositions* 8. On the utilities and excellence of Geometry

Table 1. Organization by book of early French geometries

Bovelles offered little more than a description of regularities to be found in nature, but in a couple of places he hinted at deeper reasons for such regularities, alleging that

> Ainsi appert que la Goemetrie n'est de petite utilité, par laquelle on peust cognoistre plusieurs choses dignes de scavoir. Et n'est aucunement possible, que l'engin humain puist bien profiter en la philosophie et science des choses naturelles, sans l'aide des arts mathematiques, esquelles sont contenues plusieurs mystiques, sur lesquelles se sont fondez et reiglez les anciens philosophes, pour inventer et descrire les occultes proprietez de toutes choses naturelles. [32]

> thus it appears that geometry has no little utility, by which one can know many things worth understanding. It is thus impossible that human ingenuity [*l'engin humain*] benefit in philosophy and the sciences of natural things, without the aid of mathematical arts, in which are contained many mysteries, on which ancient philosophers based and directed themselves in order to discover and describe the hidden properties of all natural things.

Most interestingly, his claim is not that geometry is useful to explain nature, but only that it allows one 'to discover and describe' (*inventer et descripre*) the secrets of nature—thus asserting without unveiling the causal mystery. Here 'practical' geometry

[32] Ibidem, 56r.

was a tool for practical discovery. It helped one see geometry in nature, and so manipulate nature.

The renovated *Livre singulier* of 1542 sold much better, judging by the only (albeit crude) measure we have available: surviving copies, new editions and translations.[33] One part of the explanation must be that Bovelles, with the help of Oronce Fine, had ordered some of the jumble that confounded the work of 1511. But we see this new order as a response to what Bovelles and Fine thought their public wanted, the success also tells us about that projected audience. In particular, one of the successful shifts Bovelles made between 1511 and 1542 was to add language about mathematics and the secrets of nature. The edition of 1547 only accentuated this language.

Secrets of Nature, Secrets of Industry (1547)

Most of Bovelles's additions to the 1547 edition of the *Geometrie practique* fall into the category of 'secrets of nature'. Pascal Brioist was the first to point out this language which existed already in the 1542 edition. In the prefatory poem, Oronce Fine alludes to '*secretz d'industrie*' as he exhorts 'all artisans and Mercurial people who want to find out new secrets' to adopt practical mathematics. Bovelles did offer some geometrical constructions from the artisanal tradition, such as a method for finding what 'common folk and mechanics call the lost centre' of a circle.[34]

Here we observe the difficulty of translating expertise between artisanal and learned spheres. Did such acquaintance with artisanal language mean Bovelles was

[33] See note on publishing history above (n.5).
[34] Brioist, "Les singularités de la géométrie pratique de Charles Bovelles".

writing in the tradition of artisanal secrets—secret because they belonged to the unwritten education of guilds—and so served an artisanal audience?[35] To suppose so is artificially to limit the 'secrets' tradition to just those practical recipes which belong squarely in the middle of the 'maker's knowledge'.[36] Technical books were also read for entertainment; secrets were increasingly meant to delight the *peuple moyen*, the growing public that these books meant to inform and entertain simultaneously. Bovelles's *Geometrie practique* signals the growth of an intermediate literature neither theoretically rigorous nor the unvarnished fruit of practice.

Brioist rightly observes that Bovelles meant 'to show that the immaterial mathematical ideas govern the universe of forms'.[37] One might further remark the notion of analogy that governs Bovelles's examples, highlighting how human art imitates nature. When he first describes the geometrical motion of four-legged beasts, he does so in order to point out that, in nature, rear legs are longer; likewise, wagons are best designed with larger wheels at the back.[38] He conceptualizes rivers as flowing from sources on the outside of a circle, flowing to the low point at the middle, in order to talk about 'la grande encyclie du monde universel' [the grand circle of the whole world] with its arrangement of heavy earth at the center and fire beyond the outermost sphere. In his additions to the 1547 edition, Bovelles describes the order of nature, in which the wind normally blows from east to west, moving the upper sails of a windmill in that direction, while water 'according to the order of nature' moves below an

[35] On this tradition, see Eamon W., *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton: 1994); Leong E. – Rankin A. (eds.), *Secrets and Knowledge in Medicine and Science, 1500-1800* (Farnham: 2011).
[36] For an account of 'maker's knowledge' in early modern Europe, see Pérez-Ramos A., *Francis Bacon's Idea of Science and the Maker's Knowledge Tradition* (Oxford: 1989).
[37] Brioist, "Les singularités de la géométrie pratique de Charles Bovelles".
[38] Bovelles, *Livre singulier* (1542) 50v–52r.

undershot waterwheel (unless human art arranges for a flume to oppose the order of nature [Fig. 3]).

[insert figure 3 here]

Throughout, Bovelles is eager to take everyday experiences, and then show how these either reflect nature's mathematical reasons—or a human intervention that relies on the same mathematical principles. But at no point does he rigorously account for those principles. Throughout the book he referenced 'common people' and 'children' and deployed French proverbs such as one that played on the opposition of 'sharp' and 'round':

> Ronde memoire, agu entendement,
>
> Fait l'homme habil, discret, sage, & prudent.
>
> Memoire ague, & ronde engin,
>
> Rend l'homme simple, & non fort fin. [39]

> Round memory, sharp understanding,
>
> Make man skilful, careful, wise, and sensible.
>
> Sharp memory and round wit
>
> Turn a man simple, and not so smart.

[39] Bovelles, *Geometrie practique* (1547), 65v.

Occasionally he sent his reader to experts, if they wished to learn more on the mysteries he noted. Discussing the arrangement of a living space to benefit from the most healthful winds, he advised that 'on this point one should consult the philosophers or physicians, who understand the disposition of the air and the differences of the four winds that come from the four directions'.[40]

But the *Geometrie practique* offer no explicit recipes for practice. Even if Bovelles thought that the first edition might help artisans learn better their own business, the material he added in 1547 confirms that he mostly meant to foster delight and wonder over such secrets rather than explain how actually to accomplish them. His first addition to the new edition was a discussion of perpetual motion. 'Each art possesses in itself some difficulty, not in transcending the power of Nature, but only the capacity and subtlety of our ingenuity'.[41] Perpetual motion thus was naturally possible, but someone had not yet discovered its secret. Bovelles added a caution: the would-be inventor should fear kings and princes, who would persecute such a discovery just as Domitian, fearing it would devalue gold, suppressed the discovery of a fabled unbreakable glass.

Bovelles's explanation of how windmills work shows that his readership could not have been artisans or practitioners. He claimed that the wind always acts on the top sails of the mill, driving the top sail around and allowing the bottom to move in reverse.[42] The explanation that the mill turns because wind above is more vigorous than

[40] Ibidem, 64v.
[41] Ibidem, 56v.
[42] Bovelles may have intended to explain by analogy with Vitruvius's observation that sails higher on a ship's mast are more effective than lower ones. *De architectura* 10.5-6. Hero of Alexandria's *Pneumatika* also described a windmill driving an organ, but made no comment on how the wind moved the sails.

wind near the ground seems to be the explanation of an observer, rather than the knowledge of artisans. Windmills of the Low Countries used sails slightly angled away from the plane of movement [Fig. 4]. By using angled sails, windmill makers evidently accounted for wind pressure directed perpendicularly to sail's plane of motion; millers had to trim their sails as often as the wind changed. Bovelles's explanation suggests that the most efficient kind of sail would have sails angled perpendicular to their plane of motion (like the vanes of a waterwheel), a construction artisans did not in fact use.[43] Based on these reasonable assumptions, there seems to be a curious disconnect between Bovelles's explanations and how artisans actually used nature. Similarly, in another passage Bovelles pointed out that one could use lines or circles as the basis for constructing typefaces—something that had to be well known to any reader of Pacioli, Dürer, or Geoffroy Tory, all widely known and available to artisans in the book trade.[44]

[insert figure 4 here]

Therefore, besides presenting geometry as useful as a kind of natural theology for recognizing the divine wisdom of numbers behind everyday objects and experiences, Bovelles meant his book to be enjoyed. He had written the practical geometry as a 'diversion', he stressed in the dedicatory letter of 1511. Both Margolin and Brioist have pointed out that in the 1542 edition Bovelles indulged in a Rabelaisian play on the

[43] On the construction of such 'post mills' see Lucas A., *Wind, Water, Work: Ancient and Medieval Milling Technology* (Leiden – Boston: 2006) 114–121.
[44] Geometry is used to design letters for type in Pacioli Luca, *Divina proportione* (Venice, Alessandro Paganini et Paganino I Paganini: 1509); Dürer Albrecht, *Underweysung der Messung mit Zirckel und Richtscheyt in Linien, Ebnen, und gantzen Corporen* (Nuremberg, Hieronymus Andreae: 1525); Tory Geoffroy, *Champfleury auquel est contenu l'art et science de la deue et vraye proportion des lettres attiques* (Paris, Olivier Mallard, for Geoffroy Tory and Gilles de Gourmant: 1529). These potential influences are mentioned by Margolin, "Une Géométrie fort singulière" 440.

microcosmic image of man, as he correlates the three lower holes in the human body (anus, genital, navel) emit elements similar to the cosmic elements (earth, water, air)—the heart correlates to fire, and appropriately remains secret, as fire apparently ought. A poem plays on the image of a broom to represent corporal punishment as the means of justice: the green bundle of twigs represent the switch for correcting youths; the thicker staff for older public offenders; while the string binding the fibers to the staff should be warning that those beyond correction may earn the hangman's noose. This collection of observations may seem harsh to modern sensibilities, but in sixteenth-century schoolyards likely served as humour.[45]

The eighth chapter was explicitly composed for useful recreation. As the largest single addition to the 1547 edition, this chapter sings the praises of geometry's 'utilities and excellencies'. Here Bovelles elucidated geometry's place among the quadrivium and walked his reader through ways geometry permitted one to deduce the size of stars and the distances of planets, as well as observe the nobility of the sun as the only planet without an epicycle—a fit image of human reason (while the other planets befit the wandering senses). Bovelles presented this as 'a little digression' to show the subaltern dependence of astronomy on geometry, as with perspective and the science of weights.[46] The mention of the mixed science of weights permitted Bovelles once again to digress into a list of secrets of nature: the diverse weights of kinds of earth and metals, the rare wood Gaiac (the remedy for syphilis), and the relative weights of food such as bread and cheese (the sort the Spanish called 'fermage' because it closes both meal and

[45] I go with caution here. After Huizinga J., *The Waning of the Middle Ages* (Toronto: 1954), historians have worried that the association of late medieval/Renaissance with macabre has been overplayed; but literary historians have still found the macabre a present feature of early sixteenth-century intellectual life. A *locus classicus* on the humorous elements of the macabre, extending Huizinga's own reflections on *homo ludens*, is also Bakhtin M., *Rabelais and His World*, trans. H. Iswolsky (Bloomington, 2009) 51.

[46] Bovelles, *Geometrie practique* (1547) 68r: 'Ici avons faict une petite evagation'.

stomach). Bovelles designated this string of remarkable observations 'a joyous digression, in order to entertain and please the reader'.[47]

Conclusion

Bovelles's practical geometry illuminates the source and aims of a genre that historians of science and technology have observed became 'popular' and widely diverse throughout Europe, from cosmographies and mapmaking manuals to instruction pamphlets sold with instruments.[48]

Bovelles (and Fine) begin to imagine a vernacular public in these books, I have suggested. It is extremely difficult to circumscribe a vernacular public, and scholars have long wrestled with the problem of who read books of secrets and other practical manuals. Like most, the *Geometrie practique* would have been of strictly limited use to actual craftsmen.[49] But it does not follow that artisans would have lacked the means to buy the books, or—more importantly—been uninterested in them. The very limited studies we have of sixteenth-century artisanal book ownership tell us that vernacular book ownership did rise considerably around mid-century.[50] Some form of literacy was

[47] Ibidem, 68v: 'une joieuse evagation, pour recreer et resiouir le lecteur'.
[48] See studies cited in note 6. Cf. exhibition catalogues of instruments: Bennett J. A., *The Measurers: A Flemish Image of Mathematics in the Sixteenth Century* (Oxford: 1995); Korey M., *The Geometry of Power: Mathematical Instruments and Princely Mechanics Around 1600* (Berlin: 2007); Gerbino A. - Johnston S., *Compass and Rule: Architecture as Mathematical Practice in England, 1500-1750* (New Haven: 2009); Dackerman S. (ed.), *Prints and the Pursuit of Knowledge in Early Modern Europe* (New Haven: 2011).
[49] A good example is the apparently practical ship-building manual by Michael of Rhodes in the late fifteenth century, which in fact omits measurements that could only be supplied by craftsmen who already knew what the book taught. Moreover, the book describes ships that were no longer being built in his time; it could not have been intended to guide the building of new ships. Long P. O. - McGee D.. - Stahl A.M. (eds.), *The Book of Michael of Rhodes: A Fifteenth-Century Maritime Manuscript, Vol. 3: Studies* (Cambridge, MA: 2009). See also Tura A., *Fra Giocondo et les textes français de géométrie pratique* (Geneva: 2008) 103. More generally, see useful studies in Damm H. – Thimann M. – Zittel C. (eds.), *The Artist as Reader. On Education and Non-Education of Early Modern Artists*, Intersections 27 (Leiden – Boston: 2013).
[50] Hackenberg M.R., "Books in Artisan Homes of Sixteenth-Century Germany", *The Journal of Library History (1974-1987)* 21, 1 (1986) 72–91. Hannah Murphy kindly shared with me Hackenberg M.R., *Private Book Ownership in Sixteenth-Century German-Language Areas*, Ph.D. Dissertation

quite widespread among the *menu peuple*; Natalie Zemon Davis judged that about half of males at the level of textile- and leatherworkers had a 'medium' literacy.[51]

This fits with the picture I have drawn. Bovelles's book captures the formation of a reading community of middling socio-economic status. Both supply and demand create this market. The 1511 edition of his *Geometrie en francoys* failed to find a market—perhaps, I would conjecture, because it was aimed primarily at the bottom rung. For it succeeded when it reached higher, to a readership that was more literate, and had more money. It is this audience, I think, that is new. The *Geometrie practique* fits in between, as a work for mid-level elites who might never dream of participating in the higher reaches of the Republic of Letters.

There is no reason to reduce this vernacular, and indeed popular, readership to something manipulated by literary elites. The demand here is not either for mechanical utility or for theoretical abstraction, but a mix of both.[52] In his ground-breaking study of early modern printed books of secrets, William Eamon sharply distinguished between 'high' contemplative understanding of nature's *arcana* and 'low' recipes based on empirical, artisanal use of nature.[53] Yet in books such as the *Geometrie practique*, these extremes mingle. In this sense, they quite naturally fit the tradition of literature on wonders, which joined the extremes of the contemplative 'high' and empirical 'low' appreciation of nature, by viewing the experience of wonders as an entrance into the secret operations of nature.[54] Although these books were often written

(University of California, Berkeley: 1983).

[51] Davis N.Z., "Printing and the People", in *Society and Culture in Early Modern France* (Stanford: 1985) 210.

[52] This mixed quality of experimental, new genres of books at the time can be seen in Horodisch A., "Die Geburt eines Kinderbuches im 16. Jahrhundert", *Gutenberg-Jahrbuch* (1960) 211–222.

[53] Eamon also distinguished between a medieval, esoteric language of secrets and early modern 'popular' secrets in newly printed books. Contrast chapters two and three of Eamon W., *Science and the Secrets of Nature*.

[54] The basic studies are Céard J., *La nature et les prodiges* (Geneva: 1996); Daston L. – Park K., *Wonders and the Order of Nature, 1150-1750* (New York: 1998); Evans R.J.W. – Marr A. (eds.),

by university-trained natural philosophers, the phenomena described in this tradition were commonplaces of the broader swathe of culture. What is worthy of note, then, is that mathematical topics too could become part of this public, vernacular culture. Neither the mathematics nor the secrets exposed in the *Geometrie practique* are deep, rigorously argued, or particularly novel. Yet the genre was new in bringing abstract mathematics together with this empirical tradition of 'secrets', for a popular readership.

In particular, I should like to highlight the fact that Bovelles's French geometries were most successful when intended for entertainment; such secrets were increasingly meant to delight the *peuple moyen*, the growing public these books aimed to inform and entertain at once.[55] Pamela Smith and Allison Kavey have both noted that readers gained from these books not some proxy for actual experience, but the sense that there were more kinds of secrets than technical ones, and that nature lay open to them if they would only look.[56] Even in the process of outlining natural theology for laymen, such books fed early modern cultures of curiosity.[57] By extension, with mathematical curiosities and entertainments, they also made mathematics into popular culture.

Curiosity and Wonder from the Renaissance to the Enlightenment (Aldershot: 2006).

[55] On reading for entertainment, see Eamon W., "How to Read a Book of Secrets", in Leong – Rankin (eds.), *Secrets and Knowledge in Medicine and Science* 23–46. The popular and entertainment value of books of secrets is also a theme in Eamon, *Science and the Secrets of Nature*, 234–266.

[56] Kavey A., *Books of Secrets: Natural Philosophy in England, 1550-1600* (Champaign, IL: 2007); Smith P.H., "What Is a Secret? Secrets and Craft Knowledge in Early Modern Europe", in Leong – Rankin (eds.), *Secrets and Knowledge in Medicine and Science* 52–54.

[57] The rise of genres of books for the curious is a recurring theme in Kenny N., *The Uses of Curiosity in Early Modern France and Germany* (Oxford: 2004); Evans and Marr, *Curiosity and Wonder*.

CAPTIONS

Fig. 1. Two methods for calculating a hollow cylinder. (a) Verney, *Collection géométrale* (c. 1530), sig. C4r, detail; (b) Bovelles, *Geometry en francoys* (Paris: 1511), 35v, detail. *Bibliothèque Municipale de Blois,* fonds ancien, Cote : I 958, and the *Bibliothèques Virtuelles Humanistes*, CESR, Tours; by permission.

Fig. 2. Bovelles, *Geometrie practique* (Regnauld Chaudière, Paris: 1551), CUL Syn.5.55.7, fol. 6r, , detail typical of Fine's decoration from 1542. This edition reused woodcuts from the editions of 1542 and 1547. (Reproduced by kind permission of the Syndics of the Cambridge University Library)

Fig. 3. Bovelles, *Geometrie practique* (Regnauld Chaudière, Paris: 1551), CUL Syn.5.55.7, fol. 58v, detail of a woodcut from 1547. (Reproduced by kind permission of the Syndics of the Cambridge University Library)

Fig. 4. Bovelles, *Geometrie practique* (Regnauld Chaudière, Paris: 1551), CUL Syn.5.55.7, fol. 57r, detail of a woodcut added in 1547. (Reproduced by kind permission of the Syndics of the Cambridge University Library)

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Two methods for calculating a hollow cylinder. (a) Verney, *Collection géométrale* (c. 1530), sig. C4r, detail. Image © Blois, Bibliothèque Municipale de Blois; (b) Bovelles, *Geometry en francoys* (Paris: 1511), 35v, detail. Image © Tours, Bibliothèques Virtuelles Humanistes, CESR.

Bovelles*, Geometrie practique* (Regnauld Chaudière, Paris: 1551), CUL Syn.5.55.7, fol. 6r, detail. Image © The Syndics of Cambridge University Library.

Bovelles, *Geometrie practique* (Regnauld Chaudière, Paris: 1551), CUL Syn.5.55.7, fol. 58v, detail of a woodcut from 1547. Image © The Syndics of Cambridge University Library.

Bovelles, *Geometrie practique* (Regnauld Chaudière, Paris: 1551), CUL Syn.5.55.7, fol. 57r, detail of a woodcut added in 1547. Image © The Syndics of Cambridge University Library.

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